SPECIAL PROJECT

WORK PLAN

SPRUCE BUDWORM LOSS ASSESSMENTS IN THE LAKE STATES, 1982

by

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INTRODUCTION

Spruce budworm (Choristoneura fumiferana (Clemens)) populations in outbreak since 1977 were drastically reduced in 1981 by natural causes. Remnant, scattered budworm populations may be found in 1982 throughout the Lake States of Michigan, Minnesota, and Wisconsin. Dead and dying white spruce (Picea glauca (Moench) Voss), black spruce (P. mariana (Mill.) B.S.P.), and balsam fir (Abies balsamea (L.) Mill.) trees can be found throughout the 3.5 million acres of spruce-fir type where budworm had been feeding.

This work plan describes the method to be used in 1982 to estimate volumes of dead trees killed by spruce budworm during the outbreaks of 1977 through 1981. Although there has been some tree mortality due to other causes such as windthrow, suppression, or root rot; and, although some spruce-fir has been harvested during the outbreaks, the survey will be conducted by trained people who will make field decisions regarding time and cause of tree death.

The methods used in this plan are adapted from standard sketchmapping techniques and H. G. Lund's 1978 publication - type maps, stratified sampling and P.P.S., U.S.D.I., BLM, Resource Inventory Note 15:1-14.

OBJECTIVES

The objectives of this survey are:

1. To record the location, extent, and intensity of defoliation caused by spruce budworm in 1982.

2. To estimate the cubic meter volume of spruce and fir killed by spruce budworm during the period 1977 through 1982 within a standard error of the mean of $\pm$ 20 percent (one standard deviation) for state and county, federal, and private ownerships in a state.

These objectives, if met, will fulfill requirements of Forest Insect and Disease Information System (FIDIS) levels I and II, except growth loss.

METHODS

Current (1982) Defoliation

Aerial sketchmapping of the spruce-fir type on all ownerships will be done in June and July when current defoliation is most evident. A high wing aircraft flying at about 1000 ft. above the terrain on 2 or 3 mile flight lines is satisfactory for seeing current defoliation. Between 10 AM and 3 PM on cloudless days seems to be the best time for maximum visibility. Two observers, one on each side of the aircraft, sketch in defoliation on 0.5 inch/mile maps that show federal, state and county, and private owndership. The minimum area of defoliation to be recorded is 12 acres. Smaller areas may be sketched in, but acreage

determination on 0.5 inch/mile maps is highly inaccurate. A dot grid may be used to estimate acres of 1982 defoliation, by ownership within each state, classified as light, moderate, or heavy. These classes are described as:

Light - 1 to 50 percent of fir and white spruce trees have light brown current foliage. Black spruce may show no browning.

Moderate - 51 to 80 percent of fir and white spruce show heavy browning or missing current foliage. There is a general thinning of foliage in the top portion of host trees.

Heavy - 81 to 100 percent of the current foliage is missing from host trees. There may be a reddish brown color to needles in the lower crowns, and top portions of the crowns are thin with only twigs apparent.

Every effort needs to be made to exclude past defoliation results and to estimate defoliation that occurred in 1982 only.

About 10 percent of the defoliated areas should be ground-checked for causal agent and mapping accuracy.

TIMBER MORTALITY

Mapping -

The location and size of spruce-fir areas where budworm have killed trees can be done by aerial survey. The survey is most readily accomplished by sketchmapping over the areas where budworm caused defoliation between 1975 and 1982. Flights conducted on bright days between 10 AM and 3 PM in July and August will reveal areas of tree mortality. If an altitude of 1000 ft. above the terrain is flown along east-west flight lines that are about 2 miles apart, dead patches of trees will easily be seen. These patches should be sketched in as accurately as possible on 0.5 inch/mile maps. One inch/mile maps would be better if available. A minimum of 12 acres should be maintained. One or two surveyors in an aircraft can accomplish this survey, but in either case, there will be considerable boxing-in and circling to accurately map tree kill.

From previous surveys we learned that tree mortality was variable between areas due to abundance of non-host trees, tree size, years of defoliation, and other reasons. We can save sampling time if we stratify the areas so that the variability is reduced. From the air, a patch of trees that appears dead may actually contain 30 to 50 percent live trees. Similarly, a patch showing just 10 dead trees in 10 acres may have twice that number of dead trees. These appearances occur because some dead trees have few branches, are intermediate crown class, are next to a hardwood, or just the tops are

dead. Variation seems greatest where many trees appear dead and smallest where there are only a few dead trees. The stratification into three levels of variation will permit putting most of the survey time into areas where variation is greatest, and the least time where variation is smallest. The 3 strata will be called severe, partial, and few, and are described as follows:

S - severe, 50 percent or more of the host trees are dead as a result of budworm attack.

P - partial, 20 to 49 percent of the host trees are dead.

F - few, 1 to 19 percent of the host trees are dead.

Cutover areas are ignored as are areas killed by beaver flooding, fire, blowdown and causes other than budworm.

Each area of dead trees is assigned a stratum as it is sketched on the map. One particular stand of spruce-fir may have all three strata represented, and each must be sketched in separately. It is important to take the time to accurately sketch in the boundaries of each stratum because those plots selected for sampling will represent all areas within the respective strata. However, the minimum sketch area is 12 acres - the smallest area that can be accurately sketched on a 0.5 inch/mile map.

NUMBER OF SAMPLES -

After the areial survey, assign a number to each mortality area within a stratum. Make a list of the areas in numerical order within each stratum then list the acreage for each area, the acreage being determined with a dot grid. Sum the area of each stratum.

Our allowable error of $\pm$ 20 percent of the mean volume of timber killed cannot be pre-determined because we don't know the mean. The 1980 survey showed a mean volume of 1.81 dead cords per acre. This value has probably increased since then to about 2 cords/acre, therefore, 20 percent of the mean would be 0.4 cords/acre. This seems an acceptable error because 0.4 cords/acre in the average 12 cord/acre stand is reasonable allowance.

The estimated variance, from experience, is:

9 in severe stratum (S)
4 in partial stratum (P)
1 in few stratum (F)

These variances are calculated from the formula:

$$s^2 = \left(\frac{\text{range of dead volume}}{4}\right)^2$$ where the range of dead cords/acre is expected to be 3-15 in S, 1-9 in P, and 0-4 in F.

The number of samples to be taken in the State is determined by the formula:

$$n = \frac{[\text{sum (As) X Sum (As X } Ss^2\text{) X } (t)^2\ ]}{(\text{sum (As)}^2\ \text{X } E^2\ \text{) + Sum (As X } Ss^2\text{)}}$$

Where As is the acreage of a stratum
t is student's t and equal to 1
E is the allowable error = 0.4
S^2 is the stratum variance

For example: Stratum S had 2,250 acres, P had 1,760 acres, and F had 635 acres. Sum was 4,645 acres.

Variance times stratum acres were:

$(A_s \text{ X } S_s^2\ )$ =	2,250 X 9 =	20,250
	1,760 X 4 =	7,040
	635 X 1 =	635
	Sum =	27,925

and substituting values in the formula:

$$n = \frac{4{,}645 \text{ X } 27{,}925 \text{ X } 1}{[(4{,}645)^2 \text{ X } .4^2\ ) + 27{,}925]}$$

$$n = \frac{129711625}{(21576025 \text{ X } .16) + 27925} = \frac{129711625}{3480089}$$

n - 37.2 rounded up to 38 sample areas in all strata in a state.

The 38 samples were distributed proportionally among the 3 strata with any stratum having a minimum of 2 samples. The number in each stratum was:

$$n_s = \frac{As}{\text{Sum } A_s} \text{ X } n$$

For severe (S) stratum:

$$n_s = \frac{2{,}250}{4{,}645} \text{ x } 38 = 18.4 \text{ or } 19 \text{ samples}$$

For partial (P) stratum:

$$n_s = \frac{1{,}760}{4{,}645} \text{ X } 38 = 14.3 \text{ or } 15 \text{ samples}$$

For few (F) stratum:

$$n_s = \frac{635}{4645} \text{ x } 38 = 5.2 \text{ or } 6 \text{ samples}$$

Rounding upward resulted in the need to take 40 samples.

SELECTION OF SAMPLE AREAS -

Each stratum is considered separately. From the list of areas, in stratum S for example, where the areas are numbered and acreages given, an accumulated acres list is made. Then a random start is used for the selection of areas to be sampled. To illustrate:

STRATUM S, severe -

AREA NO.	ACRES	ACCUMULATED ACRES
S1	41	41
S2	38	79
S3	62	141
S4	101	242
S5	87	329
S6	14	343
S7	29	372
S8	25	397
S:	:	:
:	:	:
:	:	2.250
(45)	2,250	

After the random start, sample selection is systematic on an interval calculated by:

$$I_s = \frac{As}{Ns}$$

In this case, $I_s = \frac{2,250}{19} = 118.4$

rounded down to 118 acres.

The random start is selected from between I and the I_s + the remainder. In this example, I_s is 118 and the remainder is 4. A random numbers table is used to select the start that is between 1 and 122; that is, 1 and 118 + 4.

The random number for start in the random number table is 83.

On the accumulated acreage list for stratum s, the first sample area must have an acculumated acreage of 83 or more. S1 and S2 don't make it, but S3 does, and that's the first area to be sampled in the field. The interval (118) is added to the random start (83) to find the second area to be sampled. Then, 118 + 83 = 201. On the accumulated acreage list, 201 acres come in S4, the second area to be sampled in the field. The third sample seclection is 83 + 118 + 118 = 319 which is area S5. Each successive sample area is found by adding the interval to the previous figure then finding where that acreage fits into the accumulated acreage list. Sometimes there may be a particularly large increase in the accumulated acreage list and 2 samples will be selected

from the same area number. If this is the case, data from that area are counted twice instead of taking two samples in the same area. Sample selection continues down the list until all needed sample areas have been selected. In this case, 19 sample areas will be selected.

The same procedure is used to select sample areas for the other two strata. In any case, there must be at least 2 sample areas selected in each stratum. Ownership of the sample area is relatively unimportant because all severe (s) conditions are assumed to be alike regardless of ownership. Although all sample areas may fall on private land, the data will be proportioned to acres on state, county, and federal land when final calculations are made.

The mean number of cords killed and standard error of the mean for each stratum will be calculated by Ford.

FIELD PROCEDURE -

Data from each of the sampling areas will be gathered with the aid of a 10 BAF prism used at 5 temporary points within the boundaries sketched on the areial survey map. It is important to remain inside the boundaries and to select random points within the sample area. It is best to lay out the points on the map before going into the field. Predetermine azimuth and distances. Hand compass and pacing will be sufficent for this survey. Some points will fall among non-type patches or other non-ideal spots, but it is assumed that all areas - sampled or not - are alike and that data from any one of them in a stratum is similar to data from any other area in that stratum within the variance limitation.

At each prism point classify each "in" host tree by species (fir, white spruce, or black spruce) and by condition (live or dead). If in your judgement a live tree will die within the next 2 years because of budworm attack, list it as dead. Host trees killed by some other cause are not counted. Include all host trees that died between 1977 and 1982 from budworm attack. Some of these trees will be windthrown or broken off so your best judgement will be required to call a tree "in", budworm killed since 1977, and its size. Minimum size of host trees will be 5.0 inches dbh and one 8-ft. stick to a 4 in. dib top. A calipers or diameter tape should be used to check minimum diameter.

The data from each point will be pooled for the sample area (Figure 1). Dot tally of the number of trees and number of sticks by species may be summarized on the one data sheet needed for each sample area. Volume loss per area may be calculated on the data sheet.

REPORTS

September 1 - Results of current defoliation survey including a generalized map showing areas of light, moderate, and heavy defoliation; and the total acreage in each category.

September 1 - Progress on loss assessment survey including aerial portion, sample selection, and ground work accomplished.

Final calculations and a report on the loss assessment will be required by September 30, 1983. If, however, the survey goes as expected, it may be possible to complete the report early in 1983. St. Paul Field Office personnel will assist you in data analysis portion of the report.

Figure 1. -- Field Data Sheet, Spruce Budworm Loss Assessment in the Lake States - 1982.

STATE _____ CREW _____

OWNERSHIP _____ STRATUM _____ DATE _____

AREA NO. _____

LIVE FIR		DEAD FIR	
Number	Sticks	Number	Sticks
Sum _____	_____	Sum _____	_____

Live White Spruce		Dead White Spruce	
Number	Sticks	Number	Sticks
Sum _____	_____	Sum _____	_____

Live Black Spruce		Dead Black Spruce	
Number	Sticks	Number	Sticks
Sum _____	_____	Sum _____	_____

Calculations: Total number of sticks + total number of trees = _____ ÷ 10 = cords/acre

Fir:	live _____	Dead _____	cords/a
W.S.:	live _____	Dead _____	cords/a
B.S.:	live _____	Dead _____	cords/a
Total:	live _____	Dead _____	cords/a